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BUILDER Indexes

Learning Objective

Action: Explains the types of indexes calculated by the system. Primary purpose is to ensure the participant has a clear distinction between condition and functionality in order to determine whether a facility predominately has sustainment (condition) or modernization (functionality) requirements.

Condition: In a classroom, on-line webinar or in a recorded video format, using information presented in briefing slides and references provided.

Standard: The participants will -

- Understand the building indexes used for condition assessment
- Recognize the various condition assessment approaches used in BUILDER
- Understand the strengths and weaknesses of the various condition assessment approaches
- Understand the relationship between the Component -Section Condition Index (CSCI) and Remaining Service Life and Remaining Maintenance Life
- Recognize metrics that exist within BUILDER; what they mean; why they are important to building asset management; and how they are used
- See where in BUILDER these metrics are displayed

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References

- US Army Corps of Engineers – Engineer Research and Development Center: http://www.erdc.usace.army.mil/

- Sustainment Management Systems: http://sms.cecer.army.mil/

- BUILDER Support: BuilderSupport@usace.army.mil

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Condition Assessment Objectives

- Measure "health" of specific components, systems, and buildings, preferably in real time, using multi-metrics.
- Communication tool.
- Form a basis for determining rates of deterioration for specific components, systems, and buildings.
- Form a basis for predicting condition of components, systems, buildings, and building groups.
- Compare like inventory.
- Determine current and project future budget needs and work activities.
- Used to plan and prioritize projects, allocate funds, evaluate alternate M&R strategies, establish M&R standards.

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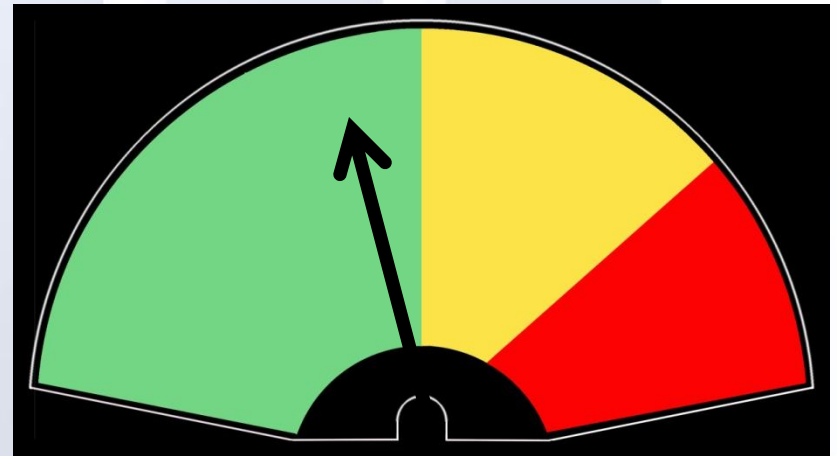
Multiple Metrics

A single metric does not meet all of the previous objectives:

- Component-Section Condition Index (CSCI)
- Component Condition Index (BCCI)
- System Condition Index (SCI)
- Building Condition Index (BCI)
- Facility Condition Index (FCI)
- Remaining Service Life (RSL)
- Functionality Index (FI)
- Mission Dependency Index (MDI)

BCI Series

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Building Condition Index Series Approach

The CERL developed condition index approach is:

- Observations-based (not backlog-based)
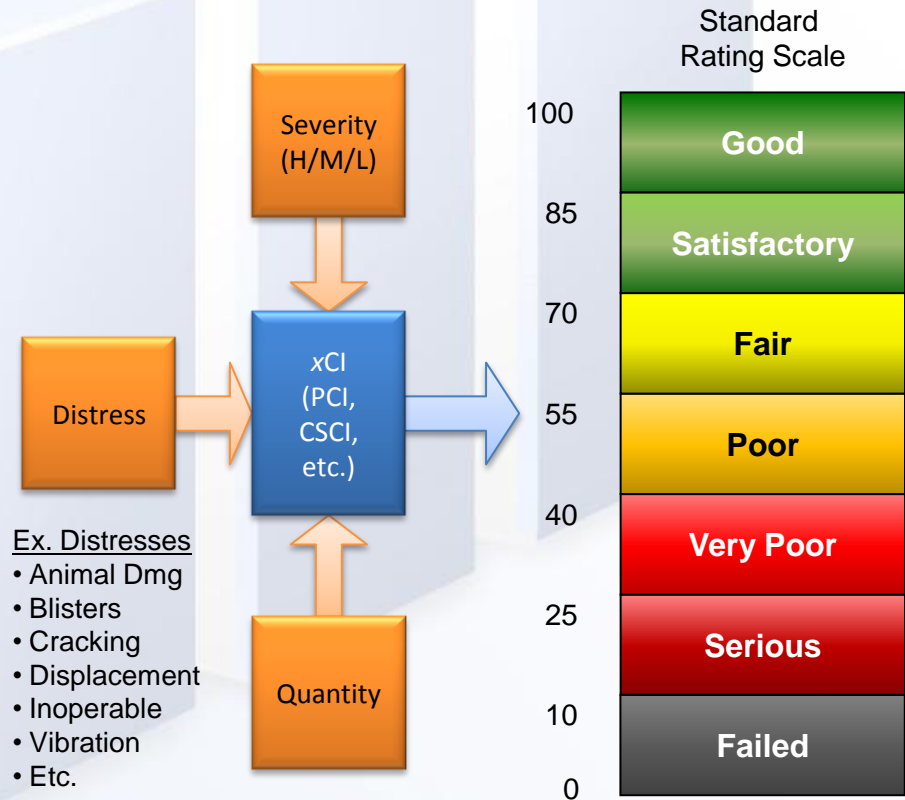- Consistent
- Repeatable
- Objective
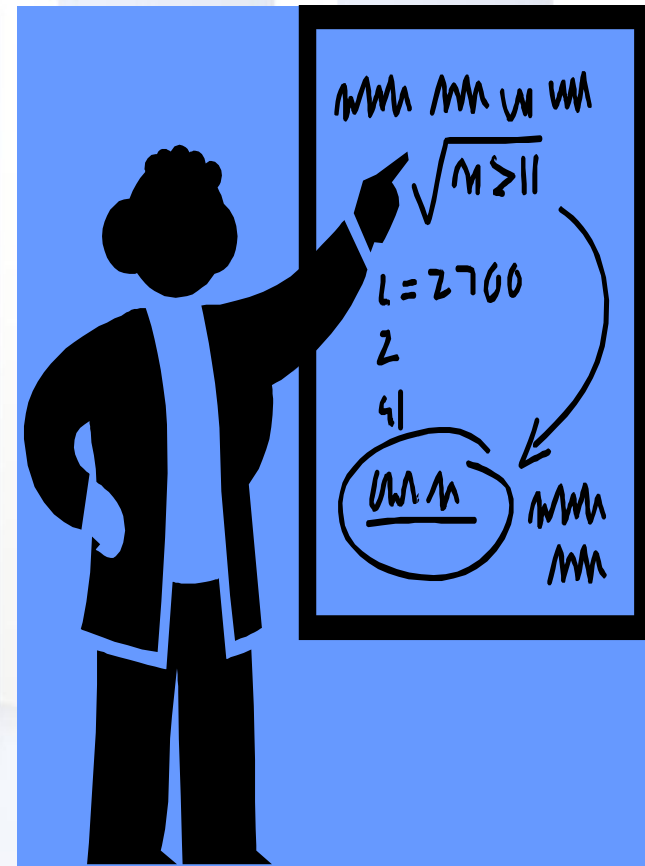
Trained technicians conduct the condition surveys and BUILDER computes the various indexes.

Distress Rating

- Utilize objective, rules-based inspection to capture consistent information set

- Models the rating that would be given by a panel of experts

- Expresses the ability of the component to continue to reliably provide the as-designed function

Severity (H/M/L)

Distress

Ex. Distresses
- Animal Dmg
- Blisters
- Cracking
- Displacement
- Inoperable
- Vibration
- Etc.

Quantity

xCI (PCI, CSCI, etc.)

Standard Rating Scale

100	Good
85	Satisfactory
70	Fair
55	Poor
40	Very Poor
25	Serious
10	Failed
0	

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Distress Definition

Blistered

Definition: Round or elongated raised areas of the subcomponent surface that are generally filled with air.

    Note: "Blistered" is a special case of deterioration. When present, record "Blistered" instead of "Deteriorated."

Severity Levels:

    Low -   The raised areas are noticeable by vision or touch.

    Medium -   Blistered area has begun to show deterioration.

    High -   Blisters are broken or worn through.

Measurement: Affected Area, Length, or Quantity, as appropriate

Density: $\frac{A}{B} \times 100$ = Problem Density

    Where: A = Affected Area, Length, or Quantity
                     B = Total Area, Length, or Quantity of Subcomponent

Distress Examples:
- Floor covering with raised area that is "soft" when walked on
- Wall covering (wallpaper) with air pocket

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Severity Levels

- Each distress has 1 to 3 different severity levels, which indicate how severely the distress affects the component's operation, mission, and life safety issues.

- Each distress-severity combination has an associated deduct curve that is a function of distress density.

- The distresses and densities present determine the deducts and the CI for each subcomponent.

Subcomponent Distress Model

Deduct Curve Development

- Deduct curves developed by presenting a diverse panel of experts with specific distress, severity, and density issues for a wide range of components.

- ie. corroded AHU drain pan, piping supports, metal panel wall, etc.

- Different severity levels: Example - Corrosion
  - If deterioration is superficial – low
  - If flaking or scaling exists – medium
  - If corrosion causes life safety problems, leaks, etc - high

Deduct Curve Data
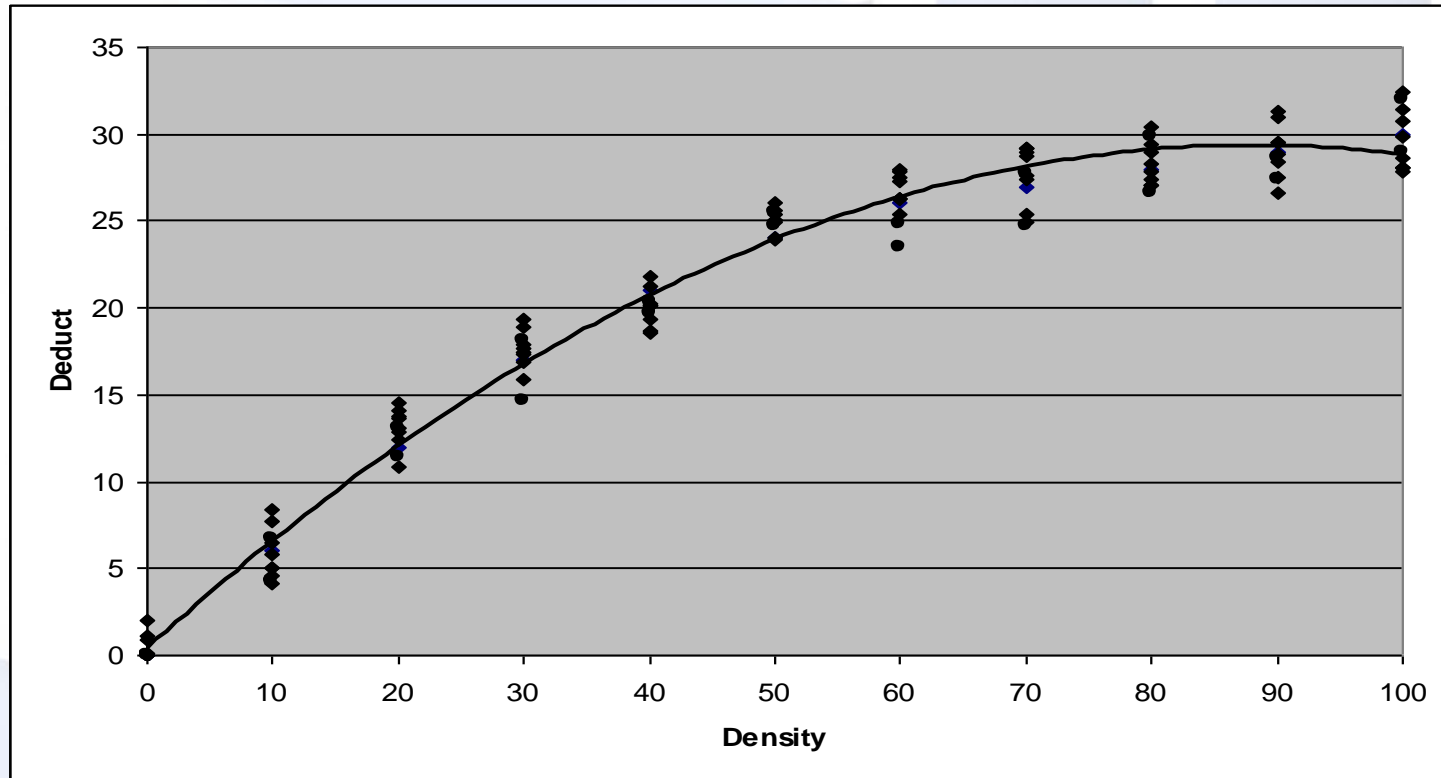
Curves developed from rating data so that 95% confidences interval is always less than plus/minus 5 points.

Multiple Distresses

- Deducts for multiple distress-severity combinations is not simply additive.

- Correction factor is applied to account for the reduced influence of any given distress when additional distresses are present.

- Present rating panel with multiple distress issues to get an aggregate CI rating.

- Plot the aggregate deduct rating versus the sum of individual deducts to determine correction factor.

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Subcomponent Weighting

- Subcomponent weight factors were developed by CERL research to indicate the relative importance of each subcomponent in terms of:
  - 1) cost to replace
  - 2) importance or criticality to overall component.
- Subcomponent weights range from 0.01 to 1.0

Component-Section CI

- Sum deduct values for each subcomponent, and apply adjustment factor to get Corrected Deduct Value (CDV).

- The subcomponent CI value is 100 – CDV.

- Average Subcomponent CIs weighted by subcomponent weight factor to get CI.

- Weights of the subcomponents with the lowest CIs are increased

- CIs can be rollup up to component, system, and building levels using weighted average approach with various metrics.

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Example: Boiler

Subcomponent	Weight	Distresses	Deduct
Boiler Tank/Enclosure	0.67	Corroded – Low 10-25%	17
Burner	0.67	Operationally Impaired – Low 100%	17
Circulating Pump	0.59	No Defects	
Receiver Tank	0.46	No Defects	
Piping/Fittings	0.38	No Defects	
Heat Exchanger	0.31	No Defects	
Blower Motor	0.26	No Defects	
Radiator/Convector	0.25	No Defects	
Sensors/Controls	0.24	No Defects	
Fan(s)	0.16 x 2.0	Excessive Vibration – Medium 100%	31
Insulation (SF)	0.15	No Defects	
Valves	0.11	No Defects	
Flue	0.09	No Defects	
Traps	0.09	No Defects	
Gauges	0.08	No Defects	
Water Drain	0.06 x 1.5	Corroded – Low 25-50%	19

Results in CI = 93

No work other than routine PM

CI = 100 – (31 x 0.16 x 2 + 19 x 0.06 x 1.5 + 17 x 0.67 + 17 x 0.67)/Sum of weights = 92.8

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Example: Boiler

Subcomponent	Weight	Distresses	Deduct	CDV
Boiler Tank/Enclosure	0.67	Corroded – Low 10-25%	17	
Burner	0.67	Operationally Impaired – Low 100%	17	
Circulating Pump	0.59 x 1.5	Leaks – Medium 100%	83	
Receiver Tank	0.46	No Defects		
Piping/Fittings	0.38 x 2.0	Corroded – High 10-25% Leaks – High 10-25%	52 83	100
Heat Exchanger	0.31	Cracked – Low 10-25%	14	
Blower Motor	0.26	No Defects		
Radiator/Convector	0.25	No Defects		
Sensors/Controls	0.24	No Defects		
Fan(s)	0.16	Excessive Vibration – Medium 100%	31	
Insulation (SF)	0.15	Deteriorated – Low 25-50%	19	
Valves	0.11	No Defects		
Flue	0.09	No Defects		
Traps	0.09	No Defects		
Gauges	0.08	No Defects		
Water Drain	0.06	Corroded – Low 25-50%	19	

Results in CI = 65

In need of major repair

CI = 100 - (100 x 0.38 x 2 + 83 x 0.59 x 2 + 31 x 0.16 + 19 x 0.15 + 19 x 0.06 + 17 x 0.67 + 17 x 0.67 + 14 x 0.31)/Sum of weights = 64.6

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Example: Boiler

Subcomponent	Weight	Distresses	Deduct	CDV
Boiler Tank/Enclosure	0.67 x 2	Corroded – Low 10-25% Cracked – High 25-50% Leaks – High 25-50%	17 80 90	100
Burner	0.67	Operationally Impaired – Low 100%	17	
Circulating Pump	0.59	Leaks – Medium 100%	83	
Receiver Tank	0.46	No Defects		
Piping/Fittings	0.38 x 1.5	Corroded – High 10-25% Leaks – High 10-25%	52 83	100
Heat Exchanger	0.31	Cracked – Low 10-25%	14	
Blower Motor	0.26	No Defects		
Radiator/Convector	0.25	No Defects		
Sensors/Controls	0.24	No Defects		
Fan(s)	0.16	Excessive Vibration – Medium 100%	31	
Insulation (SF)	0.15	Deteriorated – Low 25-50%	19	
Valves	0.11	No Defects		
Flue	0.09	No Defects		
Traps	0.09	No Defects		
Gauges	0.08	No Defects		
Water Drain	0.06	Corroded – Low 25-50%	19	

Results in CI = 51

Nearing Total Replacement

CI = 100 – (100 x 0.67 x 2 + 100 x 0.38 x 1.5 + 83 x 0.59 + 31 x 0.16 + 19 x 0.15 + 19 x 0.06 + 17 x 0.67 + 14 x 0.31)/Sum of weights = 51.3

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Direct Rating

- Based on the **Good (green), Fair (amber), Poor (red)** methodology similar to ISR
- Uses condition index scale from distress survey
- Less accurate, but faster to perform than a distress survey
- Accomplished at section level, not subcomponent
- Appropriate for when investment is not required, or when investment calls for total replacement

Condition Index Ranges

Condition Index	Definition
100	Entire component-section or sample free of observable defects
99-93	No component-section or sample serviceability or reliability reduction.
92-86	Slight or no serviceability or reliability reduction overall to component-section.
85-75	Component-section serviceability or reliability is degraded but adequate.
74-65	Component-section serviceability or reliability is definitely impaired.
64-56	Component-section has significant serviceability or reliability loss.
55-37	Significant serviceability or reliability reduction in component-section.
36-11	Severe serviceability or reliability reduction, such that it is barely able to perform.
10-0	Overall degradation is total.

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Component – Section CI (CSCI)

- Most important CI Used in BUILDER.

- Recall, the Component – Section is the basis for inventory, inspection, condition assessment, condition prediction, and M&R planning. It's the "Management Unit".

- The CSCI is the primary condition metric and a property of the "management unit".

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CSCI Purpose and Goals

- Reflect the building component – section's current ability to perform properly as it degrades from use, exposure, and/or other deterioration mechanisms.

- Establish deterioration rates, acceptable condition levels, M&R standards, and condition survey inspection needs.

- Form basis for condition prediction.

- Indicate the maintenance and repair (M&R) requirements for restoring or sustaining the component – section to an acceptable condition.

Bottom-up Condition Assessment Process

Building

Building BCI

System

System 1 SCI	System 2 SCI	System N SCI

Component

Component a BCCI	Component b BCCI	Component z BCCI

Section

Section i CSCI	Section ii CSCI	Section ii..i CSCI

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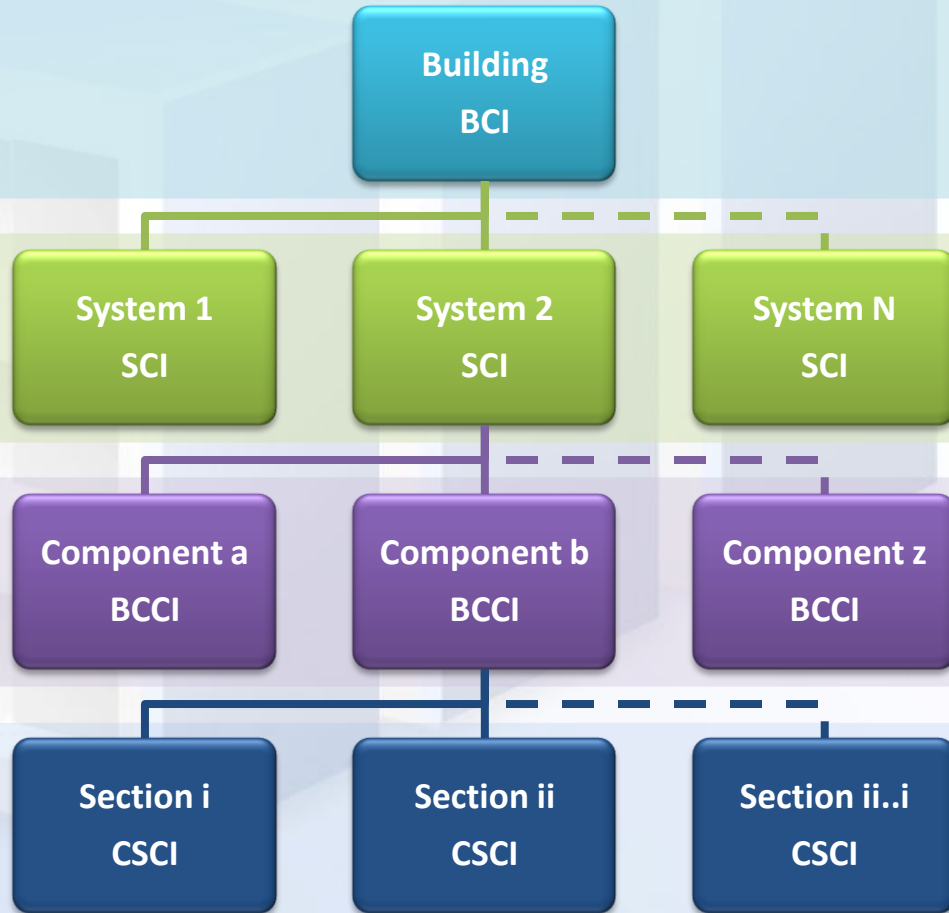
BCI Series Relationships

Building Condition Index (BCI) =
f(System Condition)

System Condition Index (SCI) =
f(Building Component Condition)

Building Component Condition Index (BCCI) =
f(Component-Section Condition)

Component-Section Condition Index (CSCI) =
f(Subcomponent Condition)

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Condition Index Color Indicators Used with BUILDER
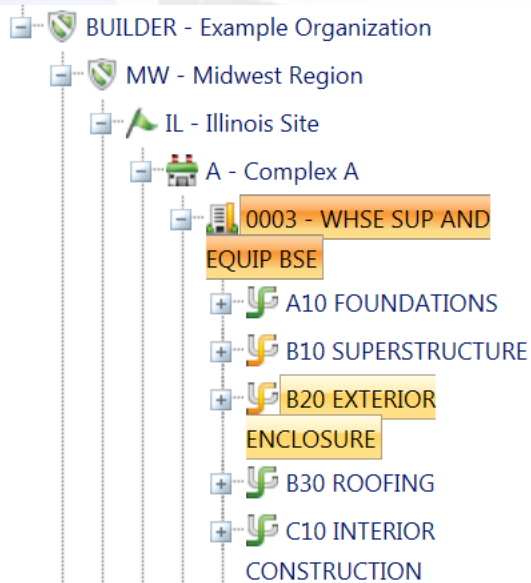
Green — • Satisfactory condition with possibly only minor M&R required.

Amber — • Adequate condition, but M&R should be considered.
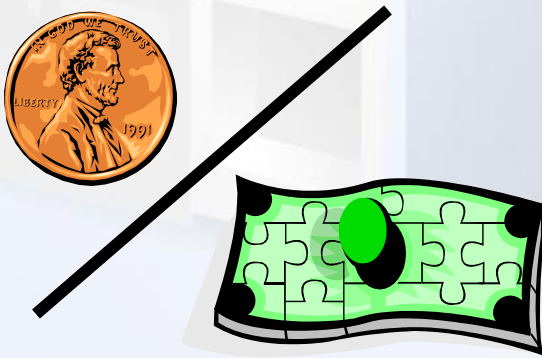
Red — • Poor condition and M&R must be accomplished.

Also used with BUILDER Direct Condition Ratings.

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Facility Condition Index (FCI)

- What is this?
  - Ratio of needed repair costs to building replacement cost.
  - BUILDER automatically computes both and the FCI.
- FCI accepted metric in "industry".
- FCI ranges established for management use, but range limits and significance are debatable.

$$FCI = \frac{\text{(penny)}}{\text{(dollar)}} \times 100$$

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Remaining Service Life

Age based life determination for building components

Sources:

- U.S. Army CERL MRPM
- Means
- BOMA
- ASHRAE
- Others

Originally developed as a tool to help forecast budget needs.

Remaining Service Life

Attractive Features:

- Simple
- Easy to understand
- Easy to use
- No inspection needed
- Basis to plan for future replacement of components
- Widely used

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Remaining Service Life

Problems with Method:

- Published data anecdotal and not building specific
- Statistical variation (mostly unknown) due to:
  - Original quality or workmanship
  - Maintenance levels
  - Use considerations
  - Climate considerations
- Determining age

BUILDER allows use of local RSL data and will adjust RSL based on computed CIs.

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Relationship between Condition and RSL

Construction/Installation
Inspection 1
Inspection 2
"Economic Sweet Spot"
Inspection 3
Condition @ Failure
Expected Srs = 20
Skip 17yrs

CI

100
80
60
40
20
0

2000 2005 2010 2015 2020 2025 2030

Year
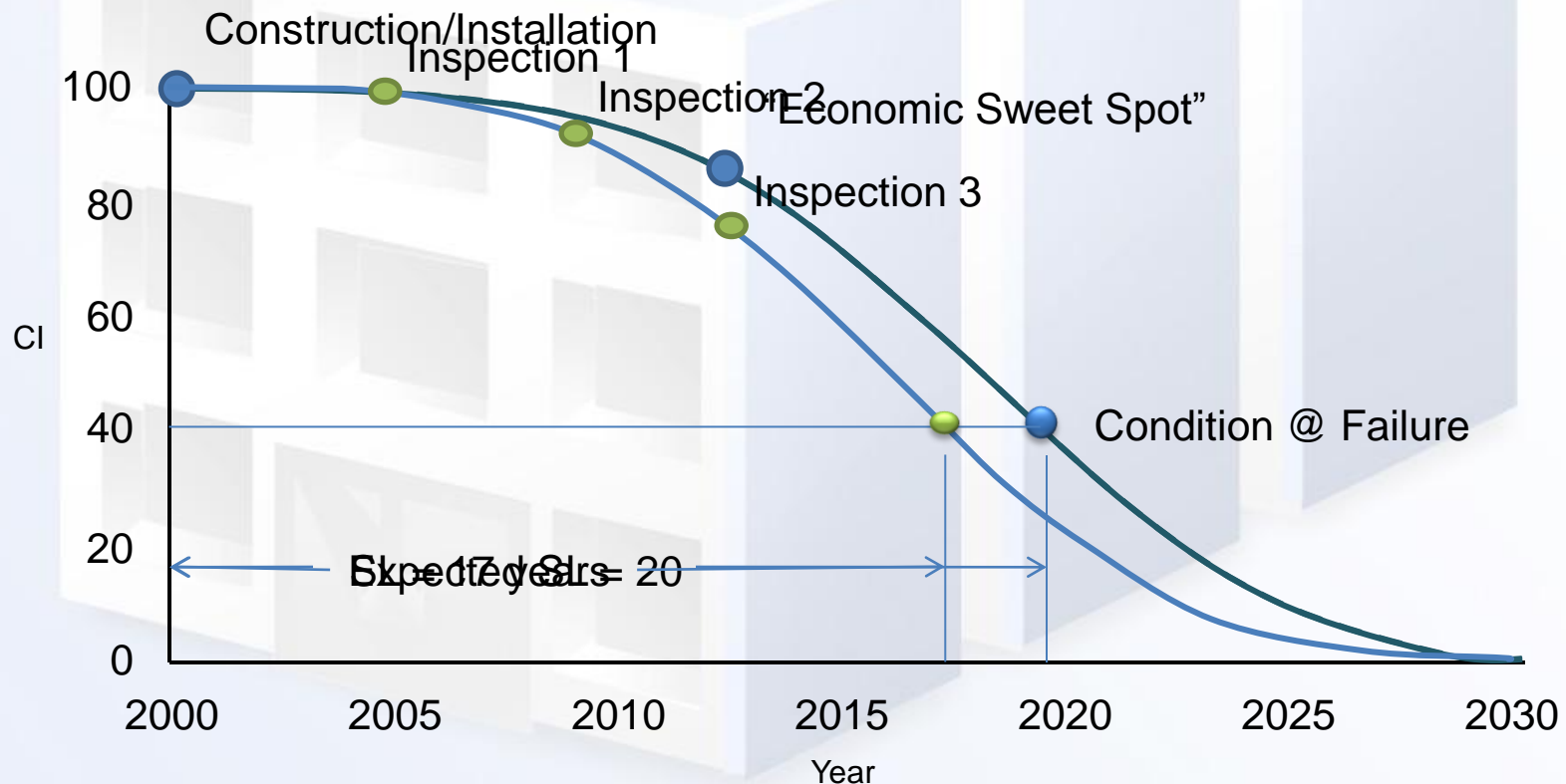
Automatically generates new **component-specific** performance profile as inspections are added

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Functionality Index (FI)

- Relates the suitability to perform the functions for which it is required (built-in capability of the asset)

- May experience loss due to changes in:
  - Occupant requirements
  - Materials or technology
  - Codes/Regulations

Functionality Index Over Life of Building
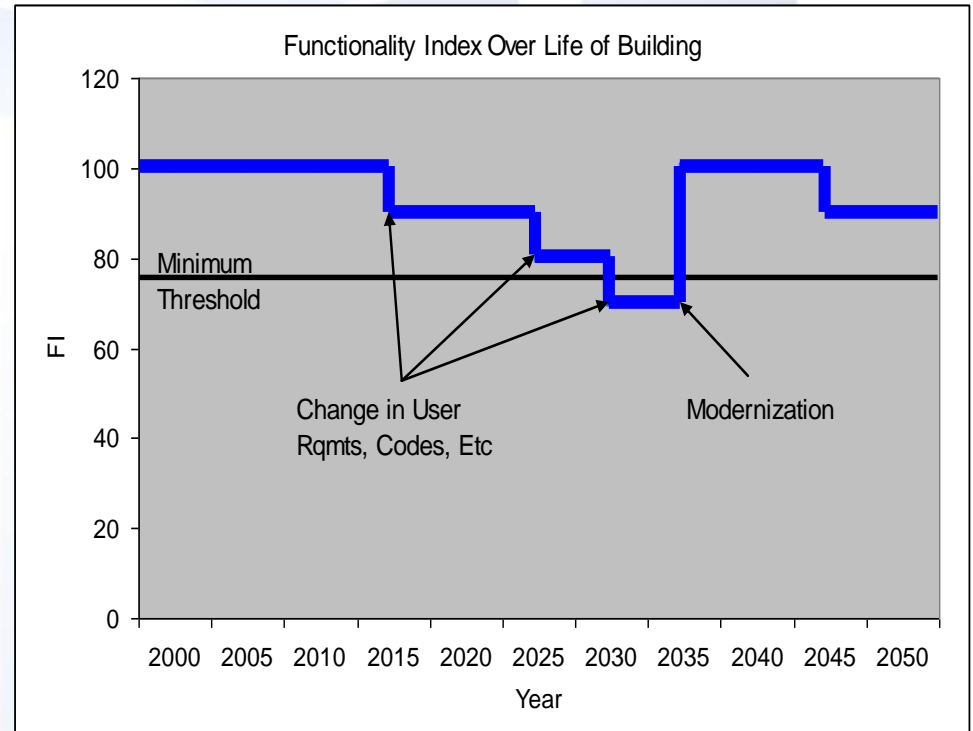
The Functionality State is improved through Facility Modernization Investments

Functionality Index

Mission Dependency Index (MDI)

- Criticality metric for facilities.
- Mission loss risk analysis features included in index.
- Developed by U.S. Navy and U.S. Coast Guard
- Allows decision makers to focus attention and resources on those facilities critical to mission accomplishment.

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Building Level SRM Analysis

Building Level Info

- **Bldg #:** 1010
- **Bldg Name:** Q Rating Example
- **Catcode:** 61010 - Administrative Office
- **Building Type:** Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms
- **Current Status:** Active
- **Type:** Permanent
- **Area:** 19,144 SF
- **Year Constructed:** 1979
- **Year Renovated:** 1999
- **Floors:** 2
- **PRV:** $3,034,000
- **Bldg Obsol Index (BFI):** 66
- **Bldg Cond Index (BCI):** 79

System Level Info

System	CRV	SFI	SCI
A10 Foundations	$117,000	96	89
B10 Superstructure	$292,000	95	94
B20 Exterior Closure	$298,200	81	74
B30 Roofing	$81,100	94	59
C10 Interior Construction	$250,700	75	80
C20 Staircases	$3,500	82	80
C30 Interior Finishes	$276,900	52	59
D10 Conveying Systems	$78,000	53	80
D20 Plumbing	$128,500	59	82
D30 HVAC	$559,500	25	77
D40 Fire Protection	$86,000	95	95
D50 Electrical	$361,450	78	83

Component Level Info

System	Component	Type Description	Qty (UM)	Installed Year	Replace Value $	Age	Obsol Index	Cond Index	RSL Initial	RSL Adjusted
A10 Foundations										
	A1010 Standard Foundations	Strip Footings	420 (LF)	1979	$23,000	32	100	95	118	102
	A1030 Slab on Grade	Plain/Reinforced	10,000 (SF)	1979	$94,000	32	95	88	43	34
B10 Superstructure										
	B1010 Floor Construction	CIP Concrete Beam and Slab	10,000 (SF)	1979	$231,000	32	95	95	43	42
	B1020 Roof Construction	Steel Deck on Beams and Bar Joist	10,000 (SF)	1999	$61,000	12	96	88	18	14
B20 Exterior Closure										
	B2010 Exterior Walls	Concrete Block	10,000 (SF)	1979	$126,000	32	90	88	28	25
	B2020 Exterior Windows	1st Floor - Steel Windows	36 (EA)	1979	$60,000	32	75	61	13	6
	B2020 Exterior Windows	2nd Floor - Steel Windows	54 (EA)	1979	$90,000	32	75	61	13	6
	B2030 Exterior Doors	Glazed Doors	4 (EA)	1979	$15,000	32	75	88	13	23
	B2030 Exterior Doors	Steel Doors	3 (EA)	1979	$7,200	32	75	80	13	16
B30 Roofing										
	B3010 Roof Coverings	Built-Up	10,000 (SF)	1999	$79,000	12	94	58	16	4
	B3020 Roof Openings	Hatches	1 (EA)	1999	$2,100	12	98	80	28	15
C10 Interior Construction										
	C1010 Partitions	1st Floor - Concrete Block	4,800 (SF)	1979	$61,000	32	95	95	43	42
	C1010 Partitions	2nd Floor - Concrete Block	5,400 (SF)	1979	$68,000	32	95	95	43	42
	C1020 Interior Doors	1st Floor - Wood Door/Metal Frame	35 (EA)	1979	$44,500	32	64	71	8	10
	C1020 Interior Doors	2nd Floor - Wood Door/Metal Frame	46 (EA)	1979	$58,000	32	64	71	8	10
	C1030 Fittings	1st Floor - Toilet Partitions	6 (EA)	1979	$9,600	32	1	30	0	0
	C1030 Fittings	2nd Floor - Toilet Partitions	6 (EA)	1979	$9,600	32	1	30	0	0
C20 Staircases										
	C2010 Stair Construction	Stairs	2 (EA)	1979	$3,500	32	82	80	18	16
C30 Interior Finishes										
	C3010 Wall Finishes	1st Floor - Wall Tile	700 (SF)	1999	$8,000	12	98	95	28	25
	C3010 Wall Finishes	2nd Floor - Wall Tile	750 (SF)	1999	$8,500	12	98	95	28	25
	C3020 Floor Finishes	1st Floor - Carpet Tile	8,000 (SF)	1999	$50,000	12	1	10	0	0
	C3020 Floor Finishes	1st Floor - Composition Sheet	1,500 (SF)	1999	$15,000	12	78	71	6	4
	C3020 Floor Finishes	1st Floor - Ceramic Tile	350 (SF)	1999	$3,700	12	99	95	38	33
	C3020 Floor Finishes	2nd Floor - Carpet Tile	8,000 (SF)	1999	$50,000	12	1	10	0	0
	C3020 Floor Finishes	2nd Floor - Composition Sheet	1,400 (SF)	1999	$14,000	12	78	71	6	4
	C3020 Floor Finishes	2nd Floor - Ceramic Tile	350 (SF)	1999	$3,700	12	99	95	38	33
	C3030 Ceiling Finishes	1st Floor - Acoustical	10,000 (SF)	1999	$62,000	12	84	88	8	9
	C3030 Ceiling Finishes	2nd Floor - Acoustical	10,000 (SF)	1999	$62,000	12	84	88	8	9